

**ENFIELD RIFLES: THE COMPOSITE CONSERVATION OF OUR
AMERICAN CIVIL WAR HERITAGE**

A Thesis

by

STARR NICOLE COX

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

December 2008

Major Subject: Anthropology

**ENFIELD RIFLES: THE COMPOSITE CONSERVATION OF OUR
AMERICAN CIVIL WAR HERITAGE**

A Thesis

by

STARR NICOLE COX

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Approved by:

Chair of Committee,	C. Wayne Smith
Committee Members,	Kevin Crisman
	James Rosenheim
Head of Department,	Donny Hamilton

December 2008

Major Subject: Anthropology

ABSTRACT

Enfield Rifles: The Composite Conservation of Our American Civil War Heritage.

(December 2008)

Starr Nicole Cox, B.A., University of Kansas

Chair of Advisory Committee: Dr. C. Wayne Smith

The object of this thesis is to discuss an experimental composite conservation process and its significance for the future of artifact conservation. Composite artifacts are artifacts comprised of multiple materials such as wood, iron, and brass. The experiment was designed around five Civil War Enfield rifles from the wreck of the Civil War blockade runner *Modern Greece*. The main conservation difficulty for both metal and wood from a saltwater site is the presence of chlorides. If not removed, the chlorides will cause the metals to further corrode. If the chlorides are left within the wood, once the wood dries the chlorides will crystallize and burst remaining cellular structure. The second major problem for wood is the cellular structure itself. Degraded waterlogged wood loses most of its cellular structure while submerged and this must be reinforced prior to drying or partial to total collapse of the wood will occur. Composite artifacts pose one more serious problem, their composite nature. In most instances treatments for one material type are damaging to the other materials present. Disassembly of an artifact often has detrimental effects on the whole artifact whether through initial damage or the inability to reassemble the artifact after stabilization.

In 1979, four Enfield rifles from *Modern Greece* were compositely conserved using either tetraethyl orthosilicate, sucrose, or isopropyl rosin. All three treatments focused on the conservation of the wood, resulting in the current poor condition of the iron elements. The research of this thesis uses the combined treatments of silicone oil (to treat the wood) and electrolytic reduction [ER] (to stabilize the metals), with minimal disassembly. It was discovered that prolonged exposure of the wood elements during ER had deleterious effects, post the silicone oil treatment. This prompted a re-evaluation of the research strategy. It was determined to do a re-treatment of the wood components of four of the rifles with silicone oil after the ER process. It was apparent during the ER process that iron components had loosened and could be removed allowing the wood to be extracted from the ER process earlier than the iron. Even though the experiment did not go as planned and the initial results were undesirable, valuable information was ascertained for treatment strategies and positive results are expected for the final four rifles. The retreatment of the wood with silicone oil should allow the wood to retain its shape, making reassembly possible.

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. C. Wayne Smith, and my committee members, Dr. Kevin Crisman, and Dr. James Rosenheim, for their guidance and support throughout the course of this research. I would also like to thank Dr. Helen Dewolf, Jim Jobling, John Hamilton and the rest of the crew out at the Conservation Research Laboratory. Without their help and guidance this project would not have been possible.

Special thanks should also be given to Nathan Henry, Assistant State Archaeologist and Conservator for the Underwater Archaeology Branch North Carolina Office of State Archaeology, who allowed me to conserve the Enfield rifles under the guidance of the Conservation Research Lab. Jonathan Swanson, Randi Sasaki, and Michael West also deserve many thanks for their repeated help with photography and x-rays.

Finally, thanks to my mother, father, and many close friends for their encouragement and for their belief in me.

TABLE OF CONTENTS

	Page
ABSTRACT	iii
ACKNOWLEDGEMENTS	v
TABLE OF CONTENTS	vi
LIST OF FIGURES	viii
 CHAPTER	
I INTRODUCTION	1
II HISTORY	4
Enfield Rifles	4
The Shipwreck <i>Modern Greece</i>	5
III REVIEW OF CONSERVATION METHODS	9
Wood	9
Metal	13
Composite Artifacts	18
IV CONSERVATION PROCEDURE	21
1979 Enfield Rifles	21
Conservation Treatments	22
Present Day Enfield Rifles	30
V RESULTS	34
MGR 014	34
MGR 005	43
MGR 007	46
MGR 013	52
MGR 015	57
Overall Results	60

CHAPTER	Page
VI CONCLUSIONS AND REMARKS	62
Significance for Conservation	62
REFERENCES CITED.....	64
APPENDIX A	67
APPENDIX B.....	69
APPENDIX C.....	81
VITA	82

LIST OF FIGURES

	Page
Figure 1 Map of the shipwreck <i>Modern Greece</i> (By Permission of the North Carolina Department of Cultural Resources)	7
Figure 2 MGR 001(left) and MGR 002 (right) (Photos by R. Sasaki)	23
Figure 3 MGR 003 (left) and MGR 004 (right) (Photos by R. Sasaki)	25
Figure 4 MGR 004 butt showing insect attack (Photo by R. Sasaki)	27
Figure 5 MGR 004 lock (Photo by R. Sasaki)	27
Figure 6 MGR 001 lock (Photo by R. Sasaki)	28
Figure 7 MGR 002 lock (Photo by R. Sasaki)	29
Figure 8 MGR 003 lock with maker's marks (Photo by R. Sasaki)	30
Figure 9 MGR 014 pre-conservation (left) and post-conservation (right) (Photos by S. Cox and R. Sasaki)	35
Figure 10 MGR 014 lock plate, hammer, tumbler, mainspring (two pieces), and hammer screw (Photo by R. Sasaki)	38
Figure 11 MGR 014 iron barrel and ramrod (Photo by R. Sasaki)	39
Figure 12 MGR 014 brass furniture (Photo by R. Sasaki)	41
Figure 13 MGR 014 maker's marks on trigger guard and trigger plate (Photos by R. Sasaki)	41
Figure 14 MGR 005 pre-conservation (Photo by S. Cox) and post-conservation barrel and ramrod (Photo by R. Sasaki)	42

	Page
Figure 15 MGR 005 lock plate with hammer, ramrod spring, and part of the mainspring (Photo by R. Sasaki)	44
Figure 16 MGR 005 brass furniture (Photo by R. Sasaki).....	45
Figure 17 MGR 005 brass maker's marks on trigger guard and trigger plate (Photos by R. Sasaki)	46
Figure 18 MGR 007 pre-conservation (Photo by S. Cox) and post-conservation barrel and ramrod (Photo by R. Sasaki).....	47
Figure 19 MGR 007 lock plate with attached hammer, rear sight (two pieces), swivel, and mainspring (two pieces) (Photo by R. Sasaki)	48
Figure 20 MGR 007 brass furniture (Photo by R. Sasaki).....	50
Figure 21 MGR 007 brass maker's marks (Photo by R. Sasaki)	50
Figure 22 MGR 013 pre-conservation (Photo by S. Cox) and post-conservation barrel and ramrod (Photo by R. Sasaki).....	51
Figure 23 MGR 013 lock plate with attached parts (Photo by R. Sasaki)	53
Figure 24 MGR 013 brass furniture (Photo by R. Sasaki).....	54
Figure 25 MGR brass maker's marks (Photos by R. Sasaki)	55
Figure 26 MGR 015 pre-conservation (Photo by S. Cox) and post-conservation barrel and ramrod (Photo by R. Sasaki).....	56
Figure 27 MGR 015 iron lock plate with hammer, mainspring (two pieces), and ramrod spring (Photo by R. Sasaki)	58
Figure 28 MGR 015 brass furniture (Photo by R. Sasaki).....	59

	Page
Figure 29 MGR 015 brass maker's marks (Photo by R. Sasaki)	60
Figure 30 Enfield rifle lock parts (Drawing by S. Cox)	67
Figure 31 Enfield rifle parts (Drawing by S. Cox)	68
Figure 32 Firearms and Ordnance page 49 (By Permission of the North Carolina Department of Cultural Resources)	69
Figure 33 Firearms and Ordnance page 50 (By Permission of the North Carolina Department of Cultural Resources)	70
Figure 34 Firearms and Ordnance page 51 (By Permission of the North Carolina Department of Cultural Resources)	71
Figure 35 Firearms and Ordnance page 52 (By Permission of the North Carolina Department of Cultural Resources)	72
Figure 36 Firearms and Ordnance page 53 (By Permission of the North Carolina Department of Cultural Resources)	73
Figure 37 Firearms and Ordnance page 54 (By Permission of the North Carolina Department of Cultural Resources)	74
Figure 38 Firearms and Ordnance page 55 (By Permission of the North Carolina Department of Cultural Resources)	75
Figure 39 Firearms and Ordnance page 56 (By Permission of the North Carolina Department of Cultural Resources)	76
Figure 40 Firearms and Ordnance page 57 (By Permission of the North Carolina Department of Cultural Resources)	77

	Page
Figure 41 Firearms and Ordnance page 58 (By Permission of the North Carolina Department of Cultural Resources)	78
Figure 42 Firearms and Ordnance Plate VI (By Permission of the North Carolina Department of Cultural Resources)	79
Figure 43 Firearms and Ordnance Plate VII (By Permission of the North Carolina Department of Cultural Resources)	80
Figure 44 Table of brass maker's marks	81

CHAPTER I

INTRODUCTION

As society and time move ever forward, we begin to forget the things we have learned in the past. Historians, archaeologists, and artifact conservators all work together relearning and remembering our past so that we do not forget important lessons. Our past shows us much about who we are and who we will become. While it is obvious how historians and archaeologists work towards this goal, it may be less clear how artifact conservation plays its part. Artifact conservators work to stabilize items from the past so that they can be studied by present and future generations. Without artifact conservation, everyday items from our past begin to disappear along with the knowledge those items imparted.

While there are many known useful techniques for artifact conservation, no process is perfect. There is always a need for research into better methods. As technologies advanced throughout past ages, the goods being produced and used by societies became more complex. Today, as conservators stabilize increasingly complex objects, conservation techniques used must also progress to meet the needs of the artifact. For example, there are several good techniques for conserving wood and iron, but very few suitable techniques that can conserve an artifact made of both wood and iron.

This thesis follows the style of *American Antiquity*.

Research in the area of composite conservation is tricky. For example, while wood and iron are plentiful and can be easily used to recreate items of the past, these recreated items will never give us the same information as the original artifact. Even if one artificially ages the wood and iron, the results of conservation on a recreated artifact will not be the same. There is no way to know exactly what an artifact has endured, so there is no way of recreating that experience. Everything can influence the degradation of archaeological materials, including the environment of the site, the other materials present at the site, in addition to how much use the item saw when it was originally created. Therefore the only reliable test of a conservation process must be performed on original artifacts, which also creates serious problems. First, all artifacts are valuable. Generally, each object holds information that cannot be gained from any other object. For this reason alone, testing new conservation techniques on artifacts is frowned upon. Should the conservation process fail, information is lost forever. Second, when doing any experiment you need to be able to recreate the experiment. This requires several of the same items, and ideally those items should have endured the same hardships. For example, if you have two Enfield rifles but one was recovered from the bottom of the ocean, and the other was recovered from a land excavation, they will be in entirely different states of preservation and the conservation results will vary just as greatly. This is difficult, because rarely does one ever find several of the same artifacts, in similar conditions, from the same site. For this reason experimentation on actual artifacts is rarely done.

Enfield rifles excavated from the Civil War-era shipwreck *Modern Greece* offer a unique opportunity to experiment with composite conservation. Enfield rifles are plentiful and much is known about them. The shipwreck *Modern Greece* provided over 215 intact rifles and rifle parts all originally shipped new, and all have endured the same environments since their sinking and recovery.

CHAPTER II

HISTORY

Enfield Rifles

The first rifle to bear the Enfield name was produced in 1853 by the Royal Small Arms Factory (RSAF) at Enfield Loch. However, not all Enfields were produced at this location. Many were produced on a contract basis through independent businesses for the British government in and around London (Bilby 1999:87). Because of British neutrality during the United States Civil War, no Enfields imported to the U.S. were from the RSAF (Beck 2000a; Bilby 1999:57). All came from the contracted suppliers the RSAF commonly used. Due to the varying production techniques, cottage-made versus factory-made, Enfield rifles are not all alike. The cottage-made industry produced hand-tooled parts, while the factory-made industry produced machine-tooled parts. Both industries were considered factories and were found in London and Birmingham. Parts were intended to be interchangeable, but most of the cottage-made varieties were comprised of non-interchangeable parts (Bilby 1999:57). Quality also varied, but overall, these were highly valued weapons, and scholars debate whether or not the Enfield was liked best or was second to the Springfield rifle. In 1861, when small arms were in short supply, the Confederacy benefited by being the first to establish contracts for these rifles. They managed to obtain contracts for most of the factory-made arms, while the Union imported more cottage-made arms (Beck 2000a; Bilby 1999:57). The factory-made Enfields were always of better quality. There were three main types of Enfields used

during the Civil War, the 39 in (99.1 cm) barrel three-banded rifle-musket, 33 in (83.8 cm) barrel two-banded rifle, and the 24 in (61 cm) barrel two-banded musketoon. There exists also an Enfield carbine, similar in size to the musketoon. The rifle-musket was the most common, and the musketoon and carbine more rare (Bilby 1999:89). Enfields for British military use were required to have walnut stocks, preferably fashioned from heartwood. Beech was only to be used as a last resort (Roads 1994, 74) In general, the stocks of the rifles sent to the states were of beech or other light wood, and stained dark (Beck 2000b). The barrels and bands are of iron as well as the percussion locks. All iron was hardened, but there was variation as to whether the barrels and bands were blued or browned to achieve this. Blueing and browning are chemical processes to harden and protect iron that impart either a blue or brown appearance to the treated metal. All butt plates, nose caps, trigger guards, and nipple cap chains were brass (Beck 2000b, Roads 1994, 76-78). Due to the vast quantity of knowledge about these rifles and many examples in existence, the Enfield is perfect for experimentation in composite artifact conservation. This is not to say that they hold no new information. Much can be obtained from proper conservation of these guns. Each gun can give information on variation within production, as well as information on where guns was produced.

The Shipwreck Modern Greece

On June 27, 1862 the steamer *Modern Greece* ran aground a half mile (0.804 km) off the coast of Fort Fisher, North Carolina while trying to run the Federal blockade on Wilmington (Figure 1). *Modern Greece*, owned by Pearson and Co. of London was

210 feet (64.01 m) in length , 29 feet (8.84 m) in breadth, and had a draught of just over 17 feet (5.18 m). She was not originally designed to be a blockade runner, but rather was pressed into service (Bright 1977, 1-6). Once aground near Fort Fisher, she was sunk by shot from both the fort protecting her approach and by the two ships working the blockade at that time; USS *Stars and Stripes* and USS *Cambridge*. Fort Fisher fired upon the *Modern Greece* to soak the large quantity of powder she carried so the vessel would not explode and salvage could be attempted. Both USS *Stars and Stripes* and USS *Cambridge* hoped to sink her and ruin all salvage possibilities (Bright 1977, 6-12). Unfortunately for them, nearly half her cargo was reportedly salvaged. Salvaged items included four 12-pound Whitworth rifled cannons, a large quantity of Enfield rifles, a large quantity of civilian goods, and the engines which were refitted into the vessel *Raleigh* (Bright 1977, 12-19).

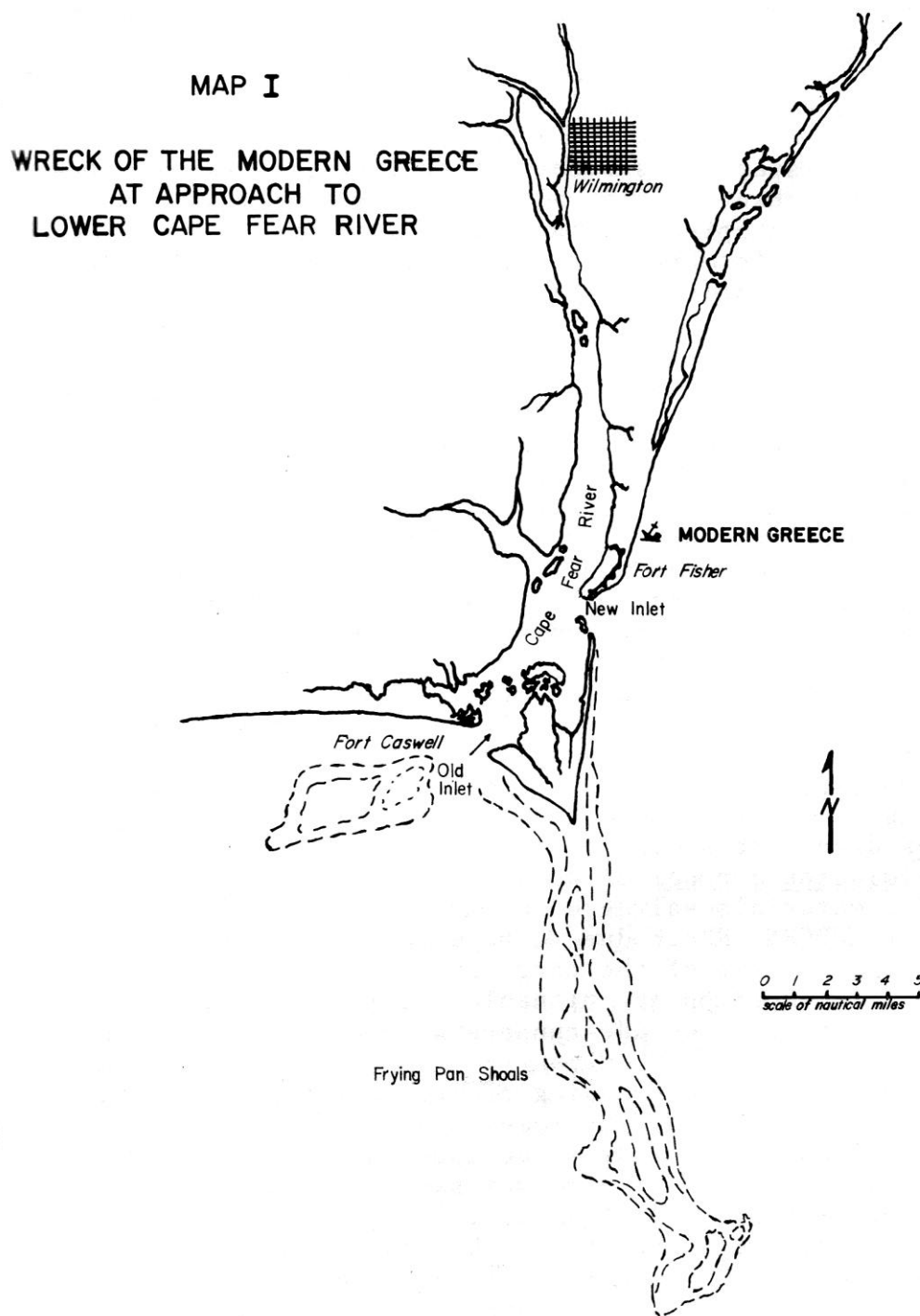


Figure 1 Map of the shipwreck *Modern Greece* (By Permission of the North Carolina Department of Cultural Resources).

In 1962, a strong storm removed the sand covering *Modern Greece*, making it possible to dive the wreck. The wreck was explored by U.S. Navy divers from the Naval Ordnance School at Indian Head, Maryland, who discovered the remaining cargo still intact. The North Carolina State Department of Archives and History, North Carolina State Confederate Centennial Commission, and the Governor's Office worked together with the Navy divers to salvage the remaining cargo. The 11,500 items recovered included but were not limited to: Enfield rifles and carbines, Whitworth shells, triangle and saber bayonets, lead and tin ingots, a brass bullet mold, the ship's anchor, tin plated steel sheets, files, handsaws, picks, knives, and some small medical tools (Bright 1977, 19-22). A reprint catalogue of the firearms and ordnance recovered from the wreck is provided in Appendix B with permission from the North Carolina Department of Cultural Resources.

Artifacts were stored and preserved at Fort Fisher State Historic Site, North Carolina. Due to the large quantity of identical items, trial and error tests for preservation were performed on the collection. The conserved artifacts are on display in a variety of locations including the Smithsonian Institution in Washington, D.C., Fort Gordon in Augusta, G.A., Mariner's Museum in Newport News, V.A., Navy Museum in Washington, D.C., and the New Hanover Museum in Wilmington, N.C. (Bright 1977, 22-23).

CHAPTER III

REVIEW OF CONSERVATION METHODS

The conservation of composite artifacts (specifically wood, iron, and brass) from water sites poses serious problems due to their composite nature. Each element comprising the artifact tends to influence the degradation of one or more of the other elements. Each element also influences the choice of techniques available to the conservator. What happens to be good for one material tends to be destructive for another. For this reason, separation of the materials is ideal. However, even this creates problems for the conservators, because the materials must be reassembled after conservation. Conservation processes are limited by the fact that separation must be performed in a way that makes reconstruction possible. Shrinkage and distortion must be controlled, and each element must be able to support the weight of the other elements. Through evaluation of the available conservation techniques, review of past composite conservation results, and evaluation of the state of degradation of each element, it is possible to create a conservation plan specific to each composite artifact.

Wood

Difficulties in Conserving Waterlogged Wood. Waterlogged wood poses serious problems for the conservator, whether from a marine or freshwater site. The main problem with extended exposure to water is the breakdown of the cellular support of the wood. The main structural support of wood is the combined strength of the cellulose and

lignin within the cell walls. After an extended period of exposure to water, cellulose disintegrates by means of hydrolysis. This leaves only the lignin behind, which is not strong enough to retain the shape of the wood after the water is removed. Depending on the length of exposure to water, the lignin may even breakdown, and the cells become virtually disconnected. The wood becomes more porous and the water fills in the gaps and continues to support the overall shape of the wood. Depending on how waterlogged the wood is upon removal from water, minimal shrinkage to total collapse of the wood can occur.

While there is a formula for determining the percent the wood is water logged ($\% = \text{wt. wet wood} - \text{wt. oven-dried wood} \div \text{wt. oven-dried wood} \times 100$), this requires a sacrificial piece of wood to be oven dried. With regards to archaeological artifacts, this is rarely plausible, and even if it were, the piece sacrificed would not reflect the state of all wood present. The degree of degradation is dependent upon type of wood, cut of wood, exposure to bacteria and other destructive elements like worms, the length of time underwater, and the presence of metallic corrosion products that permeate the wood. Wood from marine sites adds one additional problem: salts. If waterlogged wood is allowed to dry without first removing the chlorides, they will crystallize, causing further destruction of the wood by simply bursting through the fragile cells. Therefore it is extremely important that all chlorides be removed prior to any conservation treatment. The ultimate goal of waterlogged wood conservation is to remove all the remaining water with minimal shrinkage, distortion, and change in overall appearance (Cronyn 1996:250-251; Hamilton 1998: file 6; Smith 2003:21-23).

Conservation Treatments for Wood. Most conservation treatments attempt to impregnate the wood with a material that will bulk up or strengthen the cellular structure enough to allow all the water to be removed with no damage to the wood. These treatments, such as polyethylene glycol (PEG), acetone-rosin, silicone oil, and sucrose, all have their benefits and disadvantages.

PEG comes in a wide range of molecular weights, which can be combined, allowing for maximum penetration and strength. PEG is soluble in water as well as alcohols, and PEG is relatively inexpensive. However, PEG treatments can take a considerable amount of time, postponing valuable research. PEG leaves the wood with a waxy texture, greatly increases the overall weight of the object, and often obliterates diagnostic features (tool marks, maker's marks, etc.). The extra weight limits the size of potentially reconstructed items. For example, ship timbers treated with PEG weigh so much that they cannot be reconstructed without a means of external support. Another serious drawback, especially for composite artifacts, is that PEG treated wood must be kept permanently separated from any metal components, because PEG is corrosive to metals (Cronyn 1996:258; Hamilton 1998: file 6; Rodgers 1992: 32-35, 38-40; Singley 1988:61-63).

The acetone-rosin method works the same way PEG works, but is not soluble in water. Due to the need for alcohols as solvents, this method is more hazardous and expensive, but the outcome is good. The surface does not feel waxy, although a yellowish tone is imparted to the wood. This method tends to produce a lighter weight artifact than the PEG, but the most important benefit this treatment has, with regards to

composite artifacts, is that the rosin is not corrosive to metals (Cronyn 1996:258-259; Hamilton 1998: file 6; Singley 1988:63-67).

The sucrose method also works like PEG, but uses cheap, widely-available sucrose (sugar). However, this method produces wood that is dark and sticky. Great care must be taken to keep the humidity under 70 percent, or the sugar will leach out of the wood. Additives, such as pesticides and fungicides, are needed to inhibit fungal growth and insect attack. While this method will not affect metals and the cost is low, the outcome is not very pleasing (Hamilton 1998: File 6; Rodgers 1992:35-36).

The silicone oil method does not bulk like PEG, but rather coats the cell walls to provide strength and support. Any excess silicone oil is allowed to drain from the artifact before polymerization. However, due to the polymerization involved, this process is considered to be irreversible, as compared to the slightly reversible treatments listed above. Like PEG, it comes in a wide range of molecular weights, which can be combined to allow for maximum penetration. It is not soluble in water, so complete desiccation must occur before this method is applied. The outcome of this method is very pleasing. Wood is natural in color, lightweight, and sturdy enough for handling in any environment. Climate control is unnecessary and the silicone oil is recycled, which reduces the long term costs, however, the initial costs of materials are considerable. Finally, silicone oil has no negative impact on metals (Hamilton 1998: File 6; Smith 2003:23-26).

The remaining methods for treating wood, alcohol-ether, freeze drying, and camphor-alcohol, work on a slightly different theory. Each of these methods attempts to

remove all the water in a fashion that will cause minimal damage to the remaining cellular structure. While bulking agents are optional with these treatments, they are often used and at extremely low doses (10-20 percent versus 70 percent in the above treatments). They work more to consolidate the object instead of supporting it. All methods are costly, due to the labor, chemicals, or equipment involved, and most of the chemicals make the process hazardous. Each of these methods produces a wood that is extremely lightweight, with a texture and appearance akin to driftwood. The lack of bulking agents tends to increase the amount of shrinkage and distortion, but this is not always an intolerable amount. The wood tends to be brittle, and due to this, probably cannot support the metal components in a composite artifact (Hamilton 1998: File 6).

Metal

Difficulties in Conserving Iron from a Marine Site. The most prevalent iron corrosion products from marine sites include ferrous sulfide, magnetite, ferrous hydroxide, and iron chloride. These corrosion products are a result of either sulfate reducing bacteria or electrochemical corrosion processes. Both processes are very complex, and for the purpose of this paper, it is only necessary to know that iron corrodes faster in saltwater than in freshwater or air due to the chlorides present. Chlorides promote the removal of ions (oxidation) from the iron. As the iron corrodes, the byproducts accelerate the corrosion process. The process can be even further sped up in the presence of other more noble metals. Because the iron is less noble than most metals, the noble metals will steal ions from the iron to inhibit their own corrosion. As in

all conservation treatments, the goal is to stabilize the artifact. For iron, this means inhibiting further corrosion by removing the chlorides, and in some cases, reducing the corrosion layers back to metal (Cronyn 1996: 181-188, 198; Hamilton 1998: File 9; Singley 1988:49-50).

Conservation Treatments for Iron. All treatments for iron involve the removal of chlorides, whether by diffusion, electrolytic reduction (ER), or sublimation. Galvanic, ER, hydrogen reduction atmosphere, and hydrogen reduction plasma treatments all aim to reduce the existing corrosion layers back to either metal or stable corrosion products. All four of these treatments require that there be a substantial amount of metal remaining in the artifact. The galvanic and ER processes involve forcing another metal to sacrifice its ions to the unstable iron. The galvanic method does works like the processes that took place under the sea, while ER forces the ion exchange with a direct current (DC) power source. Because the current is controllable, the ER process is controllable, making it the primary choice for all iron conservation. The galvanic method is caustic and messy, and is seldom used (Cronyn 1996:199; Hamilton 1998: File 10a; Rodgers 1992:51-57; Singley 1988:52).

The hydrogen reduction atmosphere and hydrogen reduction plasma treatments both use a hydrogen rich environment at elevated temperatures to reduce the corrosion layers back to metal. The hydrogen reduction atmosphere anneals the artifact at a temperature of approximately 1000° C to 1060° C. This technique produces fabulous results and sublimates the chlorides, but changes the metallic structure of the artifact,

eliminating any future research in that area. Annealing by itself is sometimes used, but it has the same drawbacks as the hydrogen reduction atmosphere, and all the corrosion layers are lost taking the diagnostic features with them. The hydrogen reduction plasma treatment achieves the same results at a lower temperature (400° C) using radio waves. This lower temperature does not change the metallic structure, but the lower temperature will not sublime the chlorides, and they must be removed prior to treatment. These treatments are seldom used, because the equipment and materials are cost-prohibitive, and the size of the artifact must be small (Cronyn 1996: 200; Hamilton 1998: File 10b).

The alkaline-sulfite treatment works mostly to keep the artifact stable while removing the chlorides. It is performed in an air tight container under heat, which makes it difficult. Since ER is much easier and effective, this treatment is only used if an artifact is too fragile to withstand ER. Water diffusion works to remove the chlorides as well, however, it is extremely slow and the water must have an additive making it alkaline to prevent further corrosion during the process. Water diffusion often takes place during the storage of the artifact prior to treatment, but is reserved as the only treatment when an artifact is too fragile to withstand even the alkaline-sulfite treatment (Cronyn 1996: 198; Hamilton 1998: file 10b).

Finally, tannic acid is normally used in conjunction with other treatments. It is applied in several coats, and reacts with the iron oxide to form ferrous tannate, which eventually oxidizes to form ferric tannate. This imparts an appealing black surface to the artifact and acts as a chemical barrier between the remaining iron and the elements. It does nothing to the chlorides, however, so they must be removed prior to treatment. As

with all iron treatments, it is highly recommended that any tannic acid treatment be followed up with a coating of microcrystalline wax or other sealant as a physical barrier to further seal out the environment (Hamilton 1998: file 10b; Singley 1988:53).

Difficulties in Conserving Brass from a Marine Site. Brass is an alloy of copper, zinc, and often lead, but for the purpose of conservation, can be treated as if it were just copper. The most damaging element from a marine site is, again, the presence of chlorides. Because the main element in brass is copper, the brass acts as a noble metal, and can survive a marine environment relatively well. The presence of other less noble metals, such as iron, will also aid the brass in its preservation by sacrificing its ions to the brass. The most common corrosion products found are cuprous chloride and cuprous sulfide. The cuprous chlorides are highly unstable and, if left untreated once removed from the marine environment, they will eventually totally destroy brass by continually producing hydrochloric acid (HCl). This process can be stopped by either removing the chlorides, converting them to cuprous oxide, or sealing them from the atmosphere. Copper sulfides are also produced, but they only result in a discoloration and can be corrected with commercial tarnish removers after the object has been removed from water (Cronyn 1996:214-219; Hamilton 1998: file 12; Singley 1988:36-37).

Conservation Treatments for Brass. As with the conservation of iron, galvanic and ER treatments will remove the chlorides, and reduce some of the corrosion layers back to metal. Since the pros and cons of each of these treatments hold true whether for

or iron or for brass, these treatments will not be reexamined. However it must be noted that care must be taken when using ER to prevent a pink plating on the artifact (Cronyn 1996:224-226; Hamilton 1998: file 12; Rodgers 1992:68-70). The alkaline dithionite treatment will also remove the cuprous chlorides and reduce the corrosion layers back to metal. This process is the quickest of all the methods, but it will destroy any patina the artifact may have, and this is sometimes undesirable. Similar to the alkaline sulfite treatment for iron, this must also be performed in an airtight container, but no heat is required (Hamilton 1998: files 13).

There are three chemical treatment options to stabilize brass while leaving the corrosion layers intact: sodium carbonate, sodium sesquicarbonate, and benzotriazole (BTA). While sodium carbonate and sodium sesquicarbonate both react with the insoluble cuprous chlorides to create soluble sodium chlorides (and other by-products) that can be washed away, they can have good and bad effects on the patina. Sodium sesquicarbonate will not remove any patina, but in prolonged cases, can actually add a blue-green deposit to the artifact. Sodium carbonate acts more slowly with the cuprous chlorides, but can still alter the color of the patina (Hamilton 1998: File 12).

Like tannic acid in the treatment of iron, BTA is used in conjunction with all of the above methods. It can be used as the sole treatment strategy when the artifact is recovered from a freshwater site, but can also be used on artifacts with relatively low chloride levels. The BTA acts as a barrier between the cuprous chlorides and the environment preventing any further corrosion. It is recommended that an additional

sealant or physical barrier be added as an extra precaution (Cronyn 1996:228-229; Hamilton 1998:file 12).

Composite Artifacts

Difficulties in Conserving Composite Artifacts. The combination of organic materials, such as wood, and metals poses serious problems for conservators. Along with the problems established with each of the materials, most treatments for these are damaging to the other components present. For example, the most commonly used treatment on wood (PEG) is corrosive to metals, and the chemicals needed to inhibit metal corrosion destroy wood. For this reason, separation of the individual elements is ideal. However, this is not always possible without destroying some aspect of the artifact. The wood may splinter, and the iron may crumble. Even if all the components separate successfully, the conservation processes may alter the materials in such a way that they will not fit back together again. This has lead several conservators to attempt composite conservation. These conservation treatments tend to place a higher value on one material type over another, and preserve objects accordingly.

Summary of Applied Composite Conservation Treatments. Because of the lack of literature on the conservation of composite artifacts, in 1983 Janet Hawley of the conservation branch of Canada's National Historic Parks and Sites conducted a survey of the current techniques used to conserve waterlogged composite artifacts. Of the 36 conservators contacted, 21 replied. 14 claimed to have treated composites, and all

provided at least a general treatment process. The Canadian Conservation Institute (CCI) works with rosin techniques, and experiments with water soluble resins such as Conco Emulsifier, Pluracol, and Trymeen. They also were conducting experiments with PEG and a corrosion inhibitor to stop PEG's attack on metal (Hawley 1987:8-10). The Swiss National Museum, the National Museum of Denmark, and the Mary Rose Trust all practice some sort of PEG treatment for their composite artifacts (Hawley 1987:12-14).

The Florida State Department's Division of Archives, History, and Records often chooses to save one element over the others and treat the artifact accordingly. Iron undergoes electrolysis or hydrogen reduction, and wood undergoes PEG or tetraethyl orthosilicate (TEOS) treatments (this treatment will be discussed below). They were also experimenting with electrolysis in sodium carbonate to see if the wood is affected negatively. They practice the acetone-rosin method as well (Hawley 1987:11).

The National Museum of Antiquities in Scotland strictly follows the acetone-rosin method, and states that PEG is completely unsuitable for use with metal. The York Archaeological Trust and the Museum of London also follow the acetone-rosin method (Hawley 1987:11-12, 13).

The Centre d'Etude et de Traitement de Bois Gorg d'Eau treats composite artifacts with a polyester styrene resin polymerization process not unlike the silicone method discussed above. However, the process must be closely monitored because metal sometimes causes the resin to gel (Hawley 1987:13).

The Tromso Museum in Norway conserves their composite artifacts with the glycerin-Araldite method. This method is similar to the other bulking treatments with

glycerin performing the dessication, and Araldite strengthening the wood (Hawley 1987: 14-15).

The Center for Archaeological Operations in Japan uses a different method to dessicate and bulk. This process involves the use of xylene for the removal of the water, and Paraloid B72 acrylic to consolidate the artifact (Hawley 1987: 15).

Finally, The Canberra College of Advanced Education makes the claim that all composite artifacts can be separated, which may involve the use of force. Following separation, all materials are treated in one of the above described methods (Hawley 1987: 16).

CHAPTER IV

CONSERVATION PROCEDURE

1979 Enfield Rifles

In 1979, nine Enfields were given by the State of North Carolina to the Nautical Archaeology Research Laboratory, currently Conservation Research Laboratory (CRL), at Texas A&M University. All nine were excavated from the wreck *Modern Greece*. Four were conserved by various procedures that will be discussed below. One was sacrificed to see if the rifles could be dismantled and to determine the state of iron degradation. The remaining four are currently undergoing two different treatments, one of which will be discussed below. The four conservation treatments carried out in 1979 included sucrose, isopropyl-rosin (two variations), and tetraethyl orthosilicate (TEOS). There was no attempt at separation of the iron and brass elements from the wood, and in general the conservation treatments were designed specifically with the wood in mind. Although the conservation reports for only two of the rifles survived to the present, and the original tags were missing, it was possible to distinguish the methods of conservation for each gun. All the rifles were given new artifact identification designations before these distinctions were made, so the two known previous numbers do not correlate with the new numbering system.

Conservation Treatments

Artifact MGR-001 (previously MG-A-6) was conserved by the tetraethyl orthosilicate (TEOS) process (figure 2). Mechanical cleaning combined with chemical cleaning took place prior to treatment to expose as much of the original surface as possible. The rifle was assumed to already be desalinated due to the storage technique employed at Fort Fisher, so no further steps were taken to remove salts. The artifact was taken through a series of acetone baths, followed by isopropyl alcohol baths to remove most of the water. However, the goal was not to remove all the water in this process. It is necessary for the TEOS to react with the remaining inter-cellular water to form silicone dioxide. This silicone dioxide is what remains to bulk the fragile wood. Before placing the artifact in the TEOS, three quick treatments of tannic acid were applied to all the visible iron surfaces. The rifle was then allowed to soak for five days in the TEOS, which was deemed a sufficient treatment time. Finally, the brass components were polished, and the rifle was allowed to air dry (Simmons 1979:5-12).



Figure 2. MGR 001(left) and MGR 002 (right) (Photos by R. Sasaki).

Artifacts MGR-002 and MGR-003 (previously MG-A-9) were both treated with the acetone-rosin method, however, isopropyl alcohol was substituted for acetone to prevent dissolving the PVC containers (figures 2 and 3). The difference between the processes of these two artifacts is simply time. MGR-002 was immersed in isopropyl-rosin for only two months, as compared to MGR-003 which stayed in treatment for seven months (D. Hamilton to J. Hawley, letter, 21 March 1983, Conservation Research Laboratory, College Station). Preliminary encrustation removal from the rifles included mechanical and chemical cleaning. The artifacts then underwent several baths of isopropyl alcohol to dehydrate the wood. Following dehydration, tannic acid was applied in three coats to the iron elements, and the brass was polished. Finally, a 66.5 percent solution of pine rosin in isopropyl alcohol was prepared, and the rifles immersed for the previously stated periods (Cassavoy 1979:10-16).

The final rifle, MGR-004, was treated with sucrose (figure 3). Unfortunately, no conservation report survives, but the dark sticky texture of the wood, as well as a smell similar to molasses, make the conservation treatment obvious. Since the particulars of this conservation treatment are not available, the assumption will be made that it proceeded like any other sucrose method, and will not be discussed here.



Figure 3. MGR 003 (left) and MGR 004 (right) (Photos by R. Sasaki).

Since only preliminary conservation reports survive for two of the rifles from the wreck *Modern Greece*, there is no documentation on the final results. However, much can be said about the current state of these artifacts. All four Enfields were stored after treatment in the main CRL building at the Texas A&M Riverside Campus. Since this building is an old airbase firehouse, there is no climate control in the work bays. These guns hung on the wall for over 20 years. They have undergone extreme temperature changes, as well as extreme fluctuations in humidity. In other words, these artifacts have survived highly adverse conditions.

The unsightly sucrose-treated Enfield was attacked and badly eaten by insects, and was eventually sealed in a plastic bag to prevent further attack (figures 4 and 5). The high humidity has leached out a great quantity of the sugar, causing the surface of the gun to be dark, sticky, and moist. The iron has continued to corrode, and if there were any diagnostic marks, they are now gone. The brass appears to be tarnished, but this is easily remedied. In a controlled environment, the wood would probably be in much better condition, however, the iron would still be corroded. This treatment is not suitable for composite artifacts.



Figure 4. MGR 004 butt showing insect attack (Photo by R. Sasaki).



Figure 5. MGR 004 lock (Photo by R. Sasaki).

The TEOS treated rifle is in a similar state of decay (figure 6). The wood looks relatively good, but all the iron is badly corroded. The brass appears to be only tarnished, but a white residue around the trigger guard may indicate the presence of bronze disease. This treatment is not acceptable for composite artifacts.



Figure 6. MGR 001 lock (Photo by R. Sasaki).

Finally, the isopropyl-rosin treated artifacts are in varying conditions. MGR-002 (2 month immersion) is in a more heavily-deteriorated state than MGR-003 (7 month immersion). MGR-002 is in a similar state to the TEOS treated gun (figure 7). The wood looks relatively good, except for the yellow tint produced by the rosin. The iron is heavily rusted, except the barrel, which apparently separated from the wood post-

treatment and was given an additional coating of tannic acid and wax. The brass has the same tarnished look with the presence of the white residue. MGR-003 is in the best condition of all the rifles (figure 8). There is some rust on the barrel, but generally the iron looks good. The crown, date, and location marks are still visible on the lock plate. The exception to this lies under the lock plate. This iron was not given a tannic acid treatment and is heavily corroded. The brass looks tarnished, but the white residue is absent.



Figure 7. MGR 002 lock (Photo by R. Sasaki).



Figure 8. MGR 003 lock with maker's marks (Photo by R. Sasaki).

Present Day Enfield Rifles

Texas A&M University currently has ten Enfield rifles which have nearly completed their respective conservation treatments at CRL. Four of these rifles are part of the original nine received in 1979 (MGR-005 - 008). They have been stored at CRL in a covered freshwater vat that received frequent water changes to avoid growth. They are in varying states of decay, but all have a substantial amount of encrustation that encases the areas of iron and wood. Six more Enfield rifles (MGR-010 - 015) were received from Fort Fisher in 2004, all of which appear to be in slightly better condition. Five of these ten rifles (two of the original four and three of the newly received rifles) have undergone an experimental composite conservation treatment using both silicone

oil for the wood and electrolytic reduction for the metal components. They are the focus of this thesis. The remaining rifles are being conserved with more traditional methods and will serve as a comparison in a future paper. All artifacts have been x-rayed, and reveal varying amounts of iron still present under the encrustation. The brass appears tarnished, but stable.

As demonstrated by the above treatments on the four Enfields (MGR-001 - 004), the necessity for each element to receive proper treatment is paramount to the successful overall conservation of the artifact, making separation of each element seem ideal. This must be done in a manner as will cause little or no damage to each element. Finally, reassembling the finished product must be considered. However, because separation can cause damage, a treatment which allows the artifact to remain intact and still ensures proper treatment for each material would be optimum. With all these aspects in mind, an experimental composite conservation treatment involving the combined use of silicone oil and electrolytic reduction was proposed. This method was chosen for several reasons. First, when using silicone oil on wood, the outcome is very good. There is little to no shrinkage or distortion, the wood looks natural, and no special environment is needed post-treatment. Second, the nature of the silicone oil treatment allows for multiple attempts at separating the metals from the wood, which ideally will allow for the gentlest separation and retrieval of any diagnostic marks. Third, silicon oil is not detrimental to metals. And finally, ER is very effective at stabilizing both brass and iron.

The process began with mechanical and chemical cleaning. This was done until it was deemed more damaging to the materials than helpful. During this stage, any easily

removed brass furniture was removed because there is no benefit to sending metal through the silicone oil treatment if it is not necessary. These brass pieces went through electrolytic reduction (ER) and a week of boiling rinses to remove the electrolytes followed by a bath in benzotriazole (BTA) and a topical coating of Krylon 1301, a commercially available clear spray paint.

Once the mechanical and chemical cleaning ceased, the artifacts underwent a series of ten dehydration baths starting with a 25% ethanol and 75% water solution and finishing with two 100% acetone baths to ensure minimal water remains in the artifact. Next the artifacts underwent an immersion in a 20% MTMS and 80% silicone oil (2/3 SFD 1 and 1/3 SFD 5) solution. The remaining brass furniture, except for the nose caps, was removed after immersion in silicone oil. This was possible because the oil acted as a lubricant and freed the otherwise stubborn brass. Next the artifacts were polymerized by exposure to dibutyltindiacetate (DBTDA) vapor.

This is the point where the treatment became experimental. The wood was given a topical application of silicone oil for extra surface protection, and then all five rifles were placed into ER at a low current, to remove any remaining chlorides and convert iron and brass corrosion products back to a metallic state. The wood, having been treated with silicone oil, should be chemically protected from the exposure to the electrolytes necessary for ER (Dewolf 2003: personal communication) and therefore suffer little to no damage. Approximately six months into the ER process, the chlorides seemed to be tapering off, so the guns were removed and mechanically cleaned to remove any remaining encrustation that might be hindering the removal of the remaining chlorides.

At this time a few iron pieces became unattached and continued on through ER in separate vats. Also at this time a portion of the stock of MGR 014 separated from the rest of the rifle. Since there was no metal attached, it was removed from the electrolyte solution, and rinsed in a running bath for three weeks to remove any remaining electrolyte. Finally it was allowed to air dry. Based on the results of this piece of stock (which will be discussed in detail below), the procedure for the remaining rifles was reevaluated and extended. The remaining four rifles MGR 005, MGR 007, MGR 013, and MGR 015 are not complete at this time. After the butt of MGR 014 broke and was removed, the rifles were checked each week to see if more metal components could be removed, and after all metal was removed, the iron parts continued with the ER process, while the wood proceeded to rinse in running baths for three weeks. Following the baths, the wood from all of the guns except MGR 014 re-entered the silicone oil process, instead of being allowed to air dry. The reason for this will be discussed in the results below. Following ER, all iron was boiled for one week to remove the remaining electrolytes and chlorides. The iron received three applications of tannic acid, followed by a coating of microcrystalline wax. The brass nose caps which remain attached to the wood will receive a topical application of BTA as well as a coating of Krylon 1301 when the rifles finish the second treatment of silicone oil. Finally, when all procedures are complete, the iron and brass furniture will be reattached restoring the Enfield rifles to their pre-conservation appearance. Written and photographic records are being kept during the entire process.

CHAPTER V

RESULTS

MGR 014

MGR 014 (figure 9) must be discussed first, because the results of the conservation on the wood stock of this rifle changed the conservation procedure for the rest of the rifles. Six months into the ER process, the rifles were mechanically cleaned to expedite the removal of the chlorides. At this time, the butt of the stock broke away from the rest of the gun. It was removed from the electrolyte solution, rinsed, and allowed to air dry while the remainder of the rifle continued through ER. While the wood remained wet, it retained its appearance, but as it began to dry, the wood shrank and warped. This commonly happens to waterlogged wood that has not been treated, indicating that all the silicone bonds created during the silicone oil process had been severed by the extended period of submersion within sodium hydroxide. Other tests have been done at the lab with good results, which is why this experiment was set up. However, none of those artifacts were submerged for such a prolonged period. Because the butt of the stock turned out poorly and it would not be possible to reassemble the gun upon completion, it was decided to let the rest of the stock also air dry to confirm the lack of silicone bonds present. In an attempt to reestablish the silicone bonds and save the wood of the remaining four rifle stocks, they will proceed through the silicone oil process again, and those results will be discussed in a paper to come.



Figure 9. MGR 014 pre-conservation (left) and post-conservation (right) (Photos by S. Cox and R. Sasaki).

The stock of rifle MGR 014 pre-conservation measured 109.5 cm in length, which was taken to the end of the nose cap since the nose cap could not be removed. Three width measurements and three height measurements were taken at easily identifiable locations; the end of the butt, center of the lock, and just before the nose cap. These same locations were used on the other rifles when possible. The width of the butt measured 4.5 cm, the lock also measured 4.5 cm, and the area just before the nose cap measured 3.0 cm. The height of the butt measured 12.5 cm, the lock measured 5.0 cm, and the area just before the nose measured 2.5 cm. in the post-conservation stage it was impossible to get an accurate measurement of the rifle due to the manner in which it broke, however wood does not shrink longitudinally, so it is fairly safe to assume the length would have changed very little. The width measurements post-conservation were 3.3 cm at the butt, 4.5 cm at the lock, and 2.5 cm just before the nose cap. The height measurements post-conservation were 8.8 cm at the butt, 4.5 cm at the lock, and 2.1 cm just before the nose cap. The width measurements are deceptive. They appear as though nothing has significantly changed, when in fact the wood has shrunk and warped. The cross section at the lock now looks as though it is comprised of three pieces of wood instead of one, and the gaps between these warped pieces makes up a portion of the measurement. The width measurement at the nose is similarly deceptive. The nose cap is still attached to the stock, however the wood has curled in on itself. Had it not been attached to the nose cap, the wood would have curled to a greater extent. The height measurements show just how much the rifle shrank, which is similar to waterlogged wood allowed to air dry with no other conservation treatment.

The iron from MGR 014 (figures 10 and 11) that survived the long submersion in saltwater included part of the barrel and ram rod, the hammer, the lock plate with the sear attached, the mainspring, the tumbler, and some less identifiable lock parts. The barrel is 52.0 cm in length, and tapers from 2.6 cm in diameter at the breech to 1.9 cm. The ramrod is 67.2 cm in length and approximately 0.6 cm in diameter. The hammer measures 7.6 cm in height, 3.6 cm in width across the head, and is 1.4 cm thick at the head. The lock plate measures 10.7 cm in length, 3.0 cm in height, and is 0.4 cm thick. This measurement does not include the sear. The main spring is 6.2 cm in length, 2.5 cm and 0.6 cm in height at each end, and is 0.3 cm thick. The tumbler is 1.8 cm tall, 1.2 cm wide, and 0.3 cm to 1.0 cm thick. Considering the condition of these components prior to conservation, they turned out quite well. The silicone oil process slowed down the removal of chlorides through ER, but did not stop the process. There were no identifiable maker's marks present prior to conservation, and due the degraded state of the iron, none were uncovered post-conservation.



Figure 10. MGR 014 lock plate, hammer, tumbler, mainspring (two pieces), and hammer screw (Photo by R. Sasaki).



Figure 11. MGR 014 iron barrel and ramrod (Photo by R. Sasaki).

The brass from MGR 014 is the best preserved of all the elements, and following conservation, maker's marks were discovered. A complete chart of these marks, as well as the marks from the other four rifles being discussed can be found in Appendix C. This chart also shows the marks from the remaining five Enfield rifles not being discussed in this thesis. The brass furniture present on this rifle consists of two escutcheons, a trigger plate, a trigger guard, and the nose cap (figure 12). A brass butt plate probably also survived, but it was not shipped to this lab for conservation. The escutcheons measure 2.3 cm long, 1.7 cm tall, and 0.3 cm and 0.4 cm thick. The conservation turned out well, but one escutcheon suffered some damage to the inner ring upon removal from the wood. The trigger plate is 6.1 cm long and approximately 1.3 cm wide. The plate aspect of the trigger plate is 0.3 cm thick, while the tang bolt receiver and trigger pivot rise above this 0.8 cm and 1.65 cm. The tang bolt receiver is 1 cm in diameter, while the trigger pivot is 0.95 cm in diameter. The maker's marks found on the trigger plate are the number 4 and the letter H (figure 13). The trigger guard measures 18.8 cm long, with the tang measuring 1.8 high, and the guard 3.4 cm high. The width is 1.4 cm to 2.15 cm, and the thickness varies from 0.2 cm to 0.4 cm. The maker's marks found on the trigger are the letters G.II and the number 4 (figure 13). The nose cap measures 2.5 cm in length, 2.4 cm and 2.1 cm in height at each end, 2.5 cm in width, and is 0.9 cm thick at the end. This is the only nose cap that has completed conservation at this time. The nose caps remain attached to the wood stocks, and therefore will not be completed until after the wood is finished.



Figure 12. MGR 014 brass furniture (Photo by R. Sasaki).



Figure 13. MGR 014 maker's marks on trigger guard and trigger plate (Photos by R. Sasaki).



Figure 14. MGR 005 pre-conservation (Photo by S. Cox) and post-conservation barrel and ramrod (Photo by R. Sasaki).

MGR 005

Due to the results of MGR 014, the conservation of the wood for MGR 005 (figure 14) is incomplete. Therefore, only preliminary measurements are available for the stock, and we cannot yet discuss the results of the wood. The length of the stock is 107.5 cm. the stock is 5.0 cm wide at the lock and 3.0 cm wide just before the nose cap. The stock measures 5.5 cm tall at the lock and 2.3 cm just before the nose.

Considering the amount of iron present after 100 years in the ocean, the conservation turned out well. Many parts were still present, although none were complete. Surviving pieces of iron include the lock plate with attached hammer, two pieces of the barrel, the ramrod, and the ramrod spring (figures 14 and 15). The lock plate measures 11.3 cm long, 3.0 cm tall, and 0.35 cm thick. The word “TOWER” is stamped into the lock plate in front of the hammer, however, this word was not visible on any image. This is the only rifle with any remaining maker’s marks found on iron. The hammer measures 5.6 cm tall, 3.4 cm wide across the head, and 1.4 cm thick across the head. The main part of the barrel is 73.7 cm long and tapers from 2.6 cm to 1.9 cm in diameter. The small section of barrel measures 4.6 cm long, 1.6 cm wide, and 1.4 cm tall. Height is being measured on this piece instead of diameter because it has been flattened and no longer retains its original shape. The ramrod measures 85.4 cm long and is 0.6 cm in diameter. The ramrod spring is 5.3 cm long, 0.6 cm wide, and 0.2 cm to 0.3 cm thick.



Figure 15. MGR 005 lock plate with hammer, ramrod spring, and part of the mainspring (Photo by R. Sasaki).

The brass from MGR 005, like MGR 014, is the best preserved of all the elements, and in the post-conservation stage maker's marks were discovered. The brass furniture present for this rifle consists of two escutcheons, a trigger plate, a trigger guard, and the nose cap (figure 16). The escutcheons measure 2.3 cm long, 1.6 cm tall, and 0.3 cm thick. The trigger plate is 6.2 cm long and 1.3 cm wide. The plate aspect of the trigger plate is 0.3 cm thick, while the tang bolt receiver and the trigger pivot rise above this 0.85 cm and 1.7 cm. Both the trigger pivot and the tang bolt receiver are 1.0 cm in diameter. The maker's marks found on the trigger plate include a sideways H, the letters DB, the number 1, and three notches (figure 17). The trigger guard measures 19.0 cm

long, with the tang measuring 1.5 cm high, and the guard 3.5 cm high. The width is 1.3 cm to 2.1 cm, and the thickness varies from 0.2 cm to 0.4 cm. The maker's marks found on the trigger guard include the letter H and three notches (figure 17). The nose cap measures 2.5 cm in length, 2.2 cm and 1.9 cm in height at each end, 2.5 cm in width, and is 0.9 cm thick at the end.



Figure 16. MGR 005 brass furniture (Photo by R. Sasaki).



Figure 17. MGR 005 brass maker's marks on trigger guard and trigger plate (Photos by R. Sasaki).

MGR 007

Due to the results of MGR 014, the conservation of the wood for MGR 007 (figure 18) is incomplete. Therefore, only preliminary measurements are available for the stock, and we cannot yet discuss the results of the wood. The length of the stock is 102.0 cm. the stock is 5.0 cm wide at the lock and 2.7 cm wide just before the nose cap. The stock measures 6.0 cm tall at the lock and 2.3 cm just before the nose.



Figure 18. MGR 007 pre-conservation (Photo by S. Cox) and post-conservation barrel and ramrod (Photo by R. Sasaki).

The surviving iron from MGR 007 includes the lock plate with hammer, tumbler, and bridal attached, barrel, ramrod, mainspring, swivel, and rear sight (figures 18 and 19). The lock plate measures 9.9 cm long, 2.9 cm tall, and 0.1 cm thick. The hammer measures 6.8 cm tall, 3.3 cm wide across the head, and 1.3 cm thick across the head. It is not possible to obtain diagnostic measurements from the corroded tumbler and bridal. The barrel measures 100.1 cm long and tapers from 2.6 cm to 1.8 cm in diameter. The ramrod measures 65.6 cm long and 0.3 cm to 0.6 cm in diameter. The mainspring is in two pieces and they measure 4.5 cm and 3.2 cm in length and they are 0.15 cm thick. The swivel measures 3.7 cm long, 1.4 cm tall, and has a diameter of 0.5 cm thick. The rear sight measures 5.6 cm in length, 1.8 cm in width, and 0.7 to 1.3 cm tall.



Figure 19. MGR 007 lock plate with attached hammer, rear sight (two pieces), swivel, and mainspring (two pieces) (Photo by R. Sasaki).

MGR 007 has more brass furniture than any of the other rifles. The brass furniture includes two escutcheons, a trigger plate, a partial trigger guard, the brass screw from a tampion plug, the nipple cap chain, and the nose cap (figure 20). The escutcheons are 2.35 cm and 2.3 cm in length, 1.6 cm wide, and 0.3 cm and 0.2 cm thick. The smaller of the two escutcheons is missing a good portion of its inner ring. The trigger plate measures 6.15 cm in length, 1.25 cm wide, and 0.3 cm thick. The tang bolt receiver and trigger pivot stand 0.85 cm and 1.2 cm tall, and have diameters of 1.0 cm and 0.95 cm respectively. Four notches were found on the trigger plate (figure 21). The trigger guard measures 11.6 cm in length, and is missing the rear half. No maker's marks were found on the trigger guard, but they probably would have been located on the missing half and mirrored in part the marks on the trigger plate. The guard is 3.4 cm tall, the tang is 1.8 cm tall, and the entire piece varies in thickness from 0.1 cm to 0.4 cm. The tampion screw is 4.7 cm long, 0.25 cm thick with a square cross section, and bent. The head of the screw has a diameter of 1.2 cm and is 0.3 cm thick. The nipple cap chain is in two pieces. Their combined length is 9.1 cm. Each link is approximately 1.55 cm in length, except for the starting link which is 1.7 cm. The width of each link is 0.55 cm except the starting link which is 0.8 cm. The nose cap measures 2.6 cm in length, 2.1 cm and 1.8 cm in height at each end, 2.5 cm in width, and is 0.8 cm thick at the end.



Figure 20. MGR 007 brass furniture (Photo by R. Sasaki).



Figure 21. MGR 007 brass maker's marks (Photo by R. Sasaki).



Figure 22. MGR 013 pre-conservation (Photo by S. Cox) and post-conservation barrel and ramrod (Photo by R. Sasaki).

MGR 013

The wood stock from MGR 013 is the longest complete stock (figure 22). The stock measures 130.0 cm. The width of the stock measures 4.5 cm at the butt, 5.0 cm at the lock, and 3.0 cm just before the nose. The height of the stock measures 11.5 cm at the butt, 5.5 cm at the lock, and 2.5 cm just before the nose. This rifle is a true double banded short rifled musket, while the other two rifles with complete stocks are either musketoons or carbines.

The iron that survived on MGR 013 includes a good portion of the lock plate with some attached parts, the barrel, and the ramrod (figures 22 and 23). The lock plate measures 12.3 cm in length, 3.1 cm in height, and is 0.2 cm thick. The bridal is too corroded to obtain any diagnostic measurements, and the stirrup and tumbler are obscured by the bridal. The barrel measures 91.0 cm long, and tapers from 2.85 cm to 1.8 cm in diameter. The ramrod is 71.2 cm long and has a diameter of 0.6 cm. The ramrod spring measures 3.0 cm in length, 0.6 cm in width, and is 0.2 cm thick.



Figure 23. MGR 013 lock plate with attached parts (Photo by R. Sasaki).

The brass trigger guard, trigger plate, escutcheons, and nose cap all survived in excellent condition (figure 24). The trigger guard measures 18.5 cm long, with the tang measuring 1.4 cm high, and the guard 3.3 cm high. The width is 1.3 cm to 2.0 cm, and the thickness varies from 0.2 cm to 0.4 cm. The maker's marks found on the trigger guard consists of five notches, two of which are crossed (figure 25). The trigger plate measures 6.15 cm in length, 1.25 cm wide, and 0.3 cm thick. The tang bolt receiver and

trigger pivot stand 0.85 cm and 1.7 cm tall, both with diameters of 1.0 cm. five notches were found on the trigger plate, with two attempting to cross, and evidence of one mark being re-made. The letter H was also found on the trigger plate (figure 25). The escutcheons are 2.3 cm in length, 1.6 cm wide, and 0.3 cm thick. The nose cap measures 2.6 cm in length, 2.3 cm and 1.8 cm in height at each end, 2.5 cm in width, and is 0.7 cm thick at the end.



Figure 24. MGR 013 brass furniture (Photo by R. Sasaki).



Figure 25. MGR brass maker's marks (Photos by R. Sasaki).



Figure 26. MGR 015 pre-conservation (Photo by S. Cox) and post-conservation barrel and ramrod (Photo by R. Sasaki).

MGR 015

The stock of MGR 015 is most similar to the stock of MGR 014. The stock measures 109.5 cm in length (figure 26). The width of the stock measures 4.5 cm at the butt, 4.5 cm at the lock, and 3.0 cm just before the nose cap. The height measures 12.5 cm at the butt, 5.5 cm at the lock, and 2.5 cm just before the nose cap. While the length is the same, other measurements are not. These rifles were probably of the same type (musketoons or carbines) but were not exact in their manufacture.

The iron that survived includes two pieces of the barrel, a small portion of the lock plate with the hammer, bridal, and tumbler attached, the ramrod, the ramrod spring, and three pieces of the mainspring (figures 26 and 27). The breech end of the barrel measures 27.1 cm in length and tapers from 2.7 cm to 2.5 cm in diameter. The forward section of the barrel measures 38 cm in length and tapers from 2.3 cm to 2.0 cm in diameter. However the end of the barrel is incomplete, so the barrel would have a smaller diameter at the nose. The lock plate measures 8.7 cm long, 2.3 cm tall, and 0.3 cm thick. The hammer measures 6.5 cm tall, 3.5 cm wide across the head, and 1.4 cm thick across the head. The tumbler and bridal are too heavily corroded to gather diagnostic measurements. The ramrod is 41.9 cm long and has a diameter of 0.5 cm. The ramrod spring measures 4.1 cm in length, 0.55 cm in width, and is 0.2 cm thick. The mainspring is in two pieces and they measure 7.1 cm and 3.6 cm in length, 0.5 in height at the intact end, and they are both 0.9 cm wide and 0.1 cm thick.



Figure 27. MGR 015 iron lock plate with hammer, mainspring (two pieces), and ramrod spring (Photo by R. Sasaki).

The surviving brass furniture includes the escutcheons, the trigger plate, the trigger guard, and the nose cap (figure 28). The escutcheons measure 2.3 cm in length, 1.7 cm tall, and 0.35 cm and 0.4 cm thick. These escutcheons are the most robust of all the escutcheons. The trigger plate measures 6.0 cm long, 1.2 cm wide, and 0.35 cm thick. The tang bolt receiver and trigger pivot stand 0.6 cm and 1.7 cm tall with diameters of 1.0 cm each. Maker's marks found on the trigger plate include a sideways H, the letters DB, and the number 1 (figure 29). The trigger guard measures 18.4 cm in length and 1.3 cm to 2.0 cm wide. The guard stands 3.5 cm tall, and the tang stands 1.6 cm tall. No maker's marks were found on the trigger guard which may indicate that the trigger guard and trigger plate were made at separate locations. This is highly unusual

for a new firearm. If this rifle had seen action instead of ending up at the bottom of the ocean, one would assume that the trigger guard had been replaced. The nose cap measures 2.5 cm in length, 2.5 cm and 1.7 cm in height at each end, 2.5 cm in width, and is 0.7 cm thick at the end.



Figure 28. MGR 015 brass furniture (Photo by R. Sasaki).



Figure 29. MGR 015 brass maker's marks (Photo by R. Sasaki).

Overall Results

While the experimental procedure did not go as originally planned, much can be learned from the information that has been gathered and that will be gathered. While we only have the results of the wood from MGR 014, and these were poor, I am hopeful that the retreatment of the other stocks with silicone oil will produce more successful results. The wood from MGR 014 was submerged in sodium hydroxide for six to seven months, and clearly this is too long. The silicone oil bonds that had formed with the wood were all broken by the extended exposure. Many other items including rigging blocks and larger pieces of wood with iron spikes have gone through this experimental treatment

and turned out well. However, these items were not submerged in the electrolyte for as great a period. Considering what was left of the iron, the iron conservation produced desirable results. The time in ER was lengthened due to the silicone oil treatment. The silicone oil created a barrier that slowed the initial release of the chlorides, but once the chlorides started to release, they proceeded at a standard pace. Also it should be noted that while this experiment proceeded with the intent of keeping the wood and iron together as a composite artifact and therefore a composite conservation process, it could be utilized as a method to disassemble artifacts. The ER treatment loosens and exfoliates corrosion layers that cannot be reduced back to a metallic state, and this in turn loosens the corrosion bond between the wood and the iron. If the intent is not to conserve the artifact as a composite, this method could be used with careful monitoring and weekly attempts at separation. This would expose the wood for a much shorter period of time, and still allow all components to receive proper treatments.

CHAPTER VI

CONCLUSIONS AND REMARKS

Significance for Conservation

The perfect “catch all” conservation plan does not exist. Unfortunately, everything from the environment of the site to the other materials present at the site can influence the degradation of archaeological materials. These limitations do not disappear once the artifacts are retrieved and prepared for conservation. Composite artifacts, by their very nature, present even greater difficulties for the conservator. However, it is possible to overcome such difficulties. Enfield rifles from the American Civil War offer unique opportunities to discover new techniques for the conservation of composite artifacts, specifically wood, iron, and brass. Much is known about the rifles, and they are relatively plentiful. Past conservation of Enfield rifles allows for reevaluation of the processes used, and a comparison of the process being developed. At first glance the four previously treated rifles appear to have been treated in an unacceptable manner. However, they were purposely stored in undesirable conditions to test treatment viability in situations where artifacts will not have optimum conditions for storage or display. At least two of the previous treatments (isopropyl resin and sugar) would probably still be in relatively good condition if they had been stored in optimal conditions. However, eventually the untreated iron would still corrode. It would also be unfair to compare the present condition of the previously conserved rifles to the rifles in process now, because the current rifles have not endured the same harsh conditions. It would be fairly safe to

assume that the metal components of the current rifles will stand up better to time and harsh conditions, if only because they received a more appropriate treatment.

Unfortunately, only time will demonstrate the true success of this conservation treatment. If this composite silicone oil and ER treatment truly turns out well, it will eliminate the need for sacrificing one component over another, and allow all parts of composite artifacts to be effectively treated.

REFERENCES CITED

Beck, T.

2000a The Enfield Rifle Musket: The Southern Contract. Electronic document,

<http://www.civilwarguns.com/enfld11.html>, accessed October 30, 2003.

2000b The Federal Enfield. Electronic document,

<http://www.civilwarguns.com/enf2a1.html>, accessed October 30, 2003.

Bilby, J. G.

1999 *Civil War Firearms: Their Historical Background, Tactical Use and Modern Collecting and Shooting*. Combined Publishing, Conshohocken, Pennsylvania.

Bright, L.

1977 *The Blockade Runner Modern Greece and Her Cargo*. Archaeology Section, Division of Archives and History, North Carolina Department of Cultural Resources, Raleigh, North Carolina.

Cassavoy, K.

1979 Isopropyl Alcohol - Pine Resin Conservation Treatment of a Composite Artifact. Manuscript on file, Conservation Research Laboratory, Texas A&M University, College Station, Texas.

Cronyn, J. M.

1996 *The Elements of Archaeological Conservation*. Routledge, New York.

Hamilton, D.

1998 Methods of Conserving Underwater Archaeological Material Culture.

Conservation Files: ANTH 605, Conservation of Cultural Resources I. Nautical Archaeology Program, Texas A&M University, World Wide Web,
<http://nautarch.tamu.edu/class/ANTH605>.

Hawley, J.

1987 A Synopsis of current Treatments for Waterlogged Wood and Metal Composite Artifacts. Presentation given at 1987 meeting of the International Counsel of Museums, Freemantle, Australia.

Roads, C. H.

1994 *The British Soldier's Firearm 1850-1864*. Reprinted. R & R Books, New York.
Originally published 1964, Herbert Jenkins Ltd., London, England.

Rodgers, B. A.

1992 *The ECU Conservator's Cookbook: A Methodological Approach to the Conservation of Water Soaked Artifacts*. East Carolina University, Greenville, North Carolina.

Simmons, J.

1979 Tetraethyl Orthosilicate Treatment of a Compound Artifact. Manuscript on file, Conservation Research Laboratory, Texas A&M University, College Station, Texas.

Singley, K.

1988 *The Conservation of Archaeological Artifacts from Freshwater Environments*

Lake Michigan Maritime Museum, South Haven, Michigan.

Smith, C. W.

2003 *Archaeological Conservation Using Polymers: Practical Applications for*

Organic Artifact Stabilization. Texas A&M University Press, College Station,

Texas.

APPENDIX A

ENFIELD PARTS

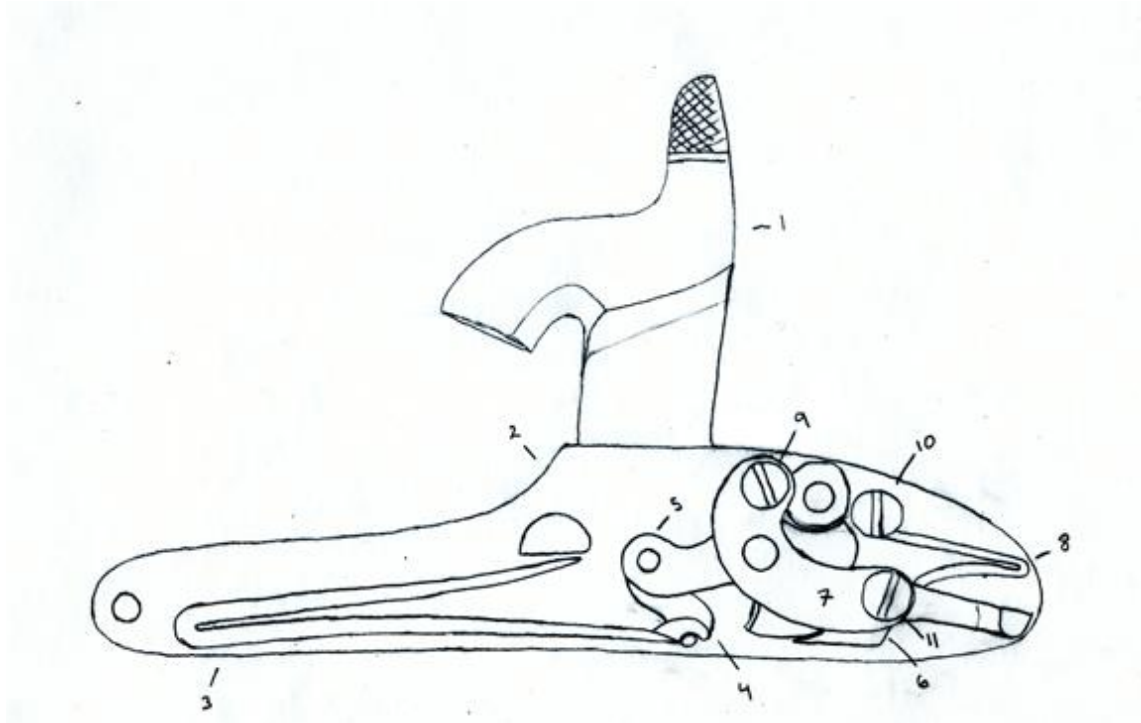


Figure 30. Enfield rifle lock parts (Drawing by S. Cox). 1. Hammer 2. Lock plate 3. Mainspring 4. Swivel 5. Tumbler 6. Sear 7. Bridle 8. Sear spring 9. Bridle screw 10. Sear spring screw 11. Sear screw

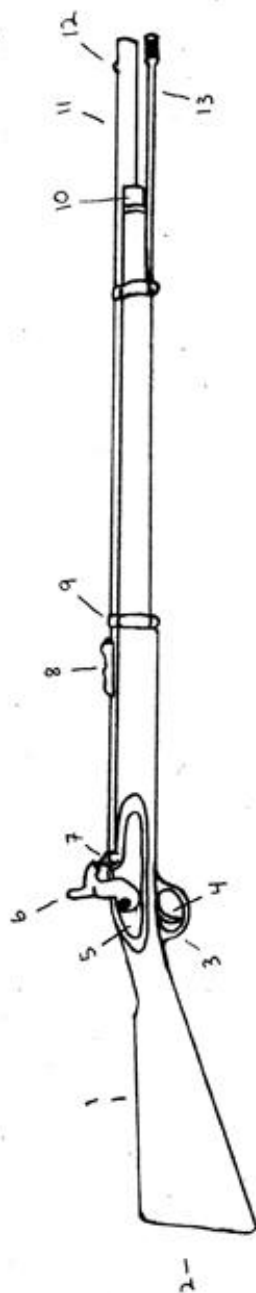


Figure 31. Enfield rifle parts (Drawing by S. Cox). 1. Stock 2. Butt 3. Trigger guard 4. Trigger 5. Lock plate 6. Hammer 7. Nipple 8. Rear sight 9. Barrel band 10. Nose cap 11. Barrel 12. Front sight 13. Ramrod

APPENDIX B

FIREARMS AND ORDNANCE

FIREARMS AND ORDNANCE

Article: Bolt, 12 pounder Whitworth (MG-2M)
 Recovered: 75
 Size: Length 9 1/2"
 Weight: 10 1/2 - 12 pounds
 Markings: None
 Description: The bolts were originally packed in cases of ten (See Figure 30). The major variance in weights is probably due to differences in the metal density. The Whitworth rifle that used these bolts was far advanced for its time with exceptional accuracy and a range of more than 9,500 yards. It was developed in England by Sir Joseph Whitworth (Ripley, 1970).
 Condition: Good
 Figure 29. Bolt, 12 pounder Whitworth
 Scale: 1/2

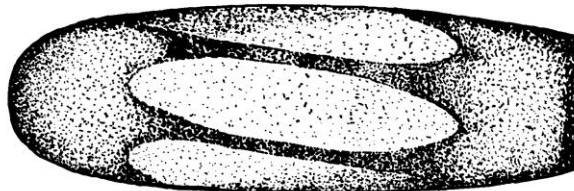


Figure 30. Whitworth packing case
 Scale: 1/4

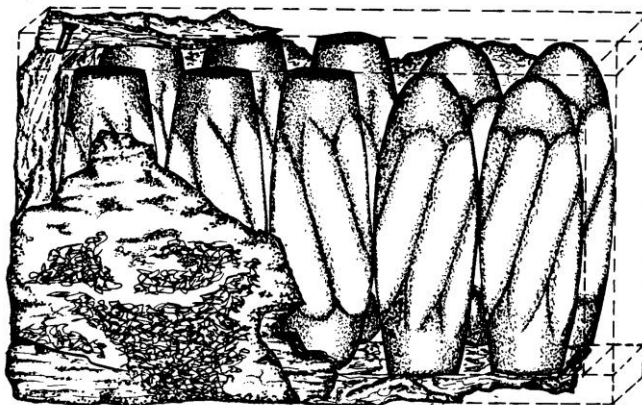


Figure 32. Firearms and Ordnance page 49 (By Permission of the North Carolina Department of Cultural Resources).

50 Firearms and Ordnance

Article: Bullet, Enfield rifle (MG-4T)
 Recovered: Several hundred
 Size: .577 caliber
 Markings: Raised markings are found on the inside of the cavity at the base of the bullet. Figure 31 illustrates the types found to date.
 Description: Most of the Enfield bullets still have boxwood plugs in their bases. A large number of bullets still remain in the aft section of the wreck. They were found in piles with their packing eroded or torn away.
 Condition: Good
 Remarks: See Appendix I for a statistical analysis of .577 caliber Enfield bullet measurements.

Figure 31. Enfield rifle bullet with raised markings found inside the base cavities. Full scale

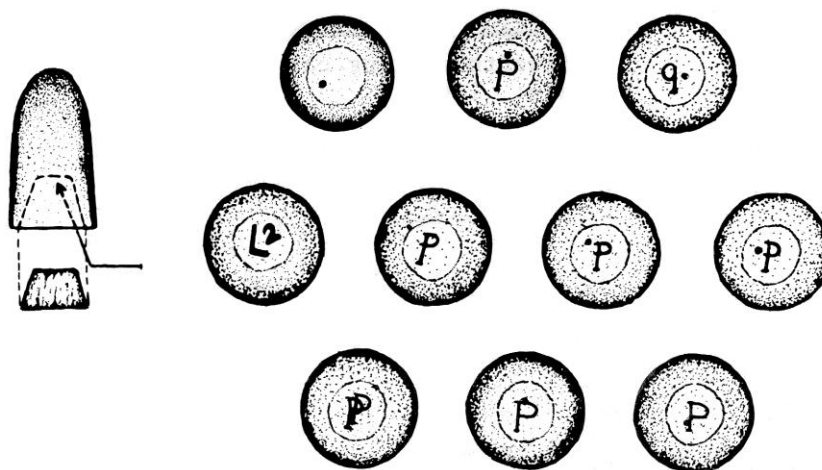
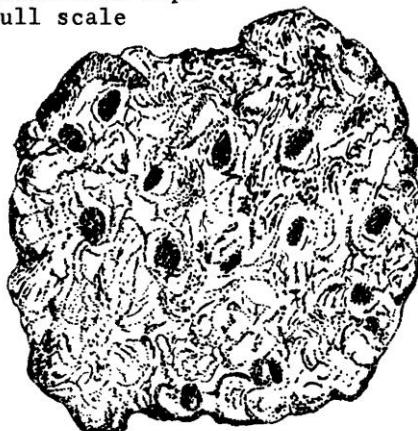


Figure 33. Firearms and Ordnance page 50 (By Permission of the North Carolina Department of Cultural Resources).

Firearms and Ordnance 51

Article: Caps, percussion (MG-2J)
 Recovered: 15 clusters
 Size: Diameter (of cluster) 3"
 Height (of cluster) 1"
 Markings: None
 Description: These percussion caps were probably for use in the Enfield rifles. About 300 caps were packed in each round metal box 3" in diameter and 1" in height. The metal boxes have disintegrated leaving only the clusters of badly deteriorated and cemented together percussion caps.
 Condition: Poor

Figure 32. Percussion caps
Full scale



Article: Mold, Enfield bullet (MG-2Z)
 Recovered: 2
 Size: Length 7 1/4"
 Cavity .577
 Markings: The number 18 appears on the bottom near the mold end.
 Description: The molds are made of brass.
 Condition: Good

Figure 34. Firearms and Ordnance page 51 (By Permission of the North Carolina Department of Cultural Resources).

52 Firearms and Ordnance

Figure 33. Mold, Enfield bullet
Full scale

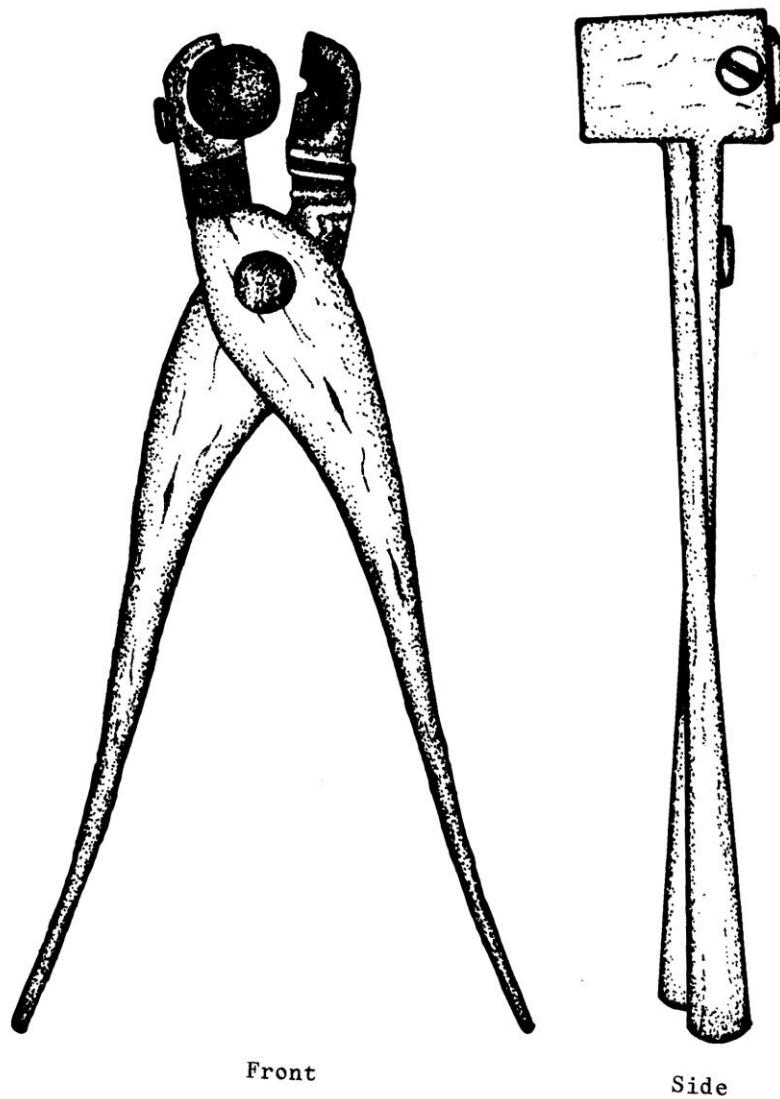


Figure 35. Firearms and Ordnance page 52 (By Permission of the North Carolina Department of Cultural Resources).

Firearms and Ordnance 53

Article: Pistol, Unwin and Rodgers knife (MG-7I)
 Recovered: 1
 Size: .28 caliber
 Markings: None
 Description: This Unwin and Rodgers knife pistol has two slots approximately 3 1/2" long and 1/4" wide located on either side of the trigger mount where the partial remains of the two blades are still visible. The trigger is decayed, and the hammer is missing. The 3 3/8" long barrel is German silver and has two starlike stamps on the left side. There are eight pins protruding from either side. These originally held the stag grips. Ten small .28 caliber shot were found in the capbox built into the rear of the hilt.
 Condition: Good
 Remarks: Since only one knife pistol was recovered with shots still in the capbox, it is assumed that this item belonged to a person on board the ship and was not part of the cargo.

Figure 34. Pistol, Unwin and Rodgers knife
Full scale

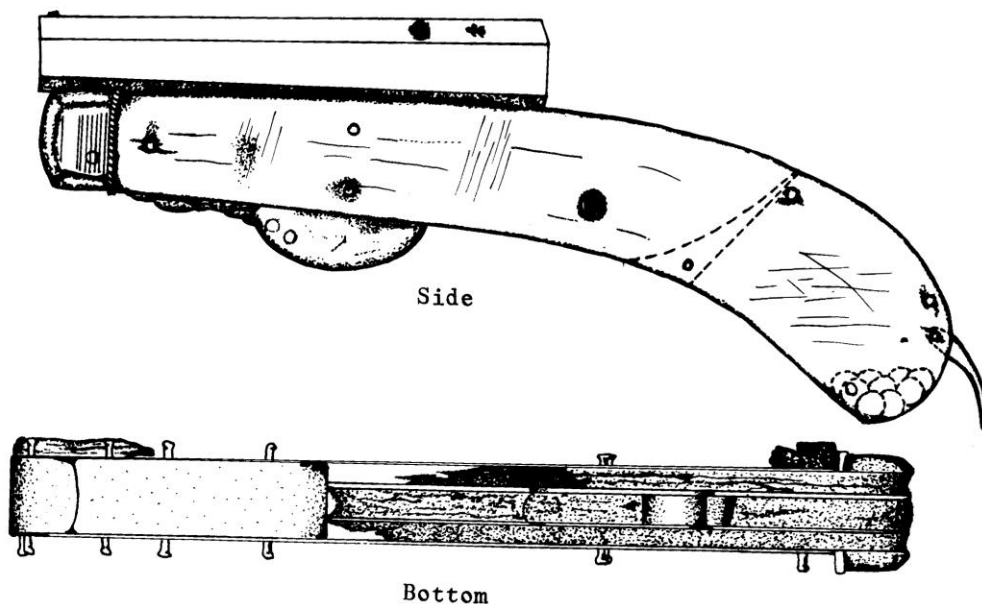


Figure 36. Firearms and Ordnance page 53 (By Permission of the North Carolina Department of Cultural Resources).

54 Firearms and Ordnance

Article: Rifle, Tower Enfield (MG-A)
 Recovered: 50 complete rifles
 215 fragments broken as follows:
 30 butt fragments
 24 butt and center fragments
 128 center and forearm fragments
 14 forearm fragments
 19 miscellaneous short fragments

Size: Caliber .577
 Length (of rifle) 58"
 Length (of carbine) 48"
 Average length (of butt fragments) 9 1/2"
 Average length (of butt and center fragments) 27 1/2"
 Average length (of center and forearm fragments) 40"
 Average length (of forearm fragments) 18"

Markings: Three rifles that have ferrous butt plates, trigger guards, trigger housings, and nose caps are stamped on hind stock Ward & Sons Makers, Birmin (See Figure 41).

Description: The rifles were originally packed in cases of twenty-four (See Figure 38). One of the boards forming the top of a case was painted with the mark illustrated in Figure 40. Leather shoulder straps were packed in one end of the boxes (See Figure 39). The 215 fragments could combine to form at least 139 Enfield rifles. Collectively, a projected total of 215 Enfield rifles were recovered from the MODERN GREECE by the State of North Carolina. An undetermined number of Enfield rifles had been recovered by others before the State claimed jurisdiction. Many of the rifles were broken during recovery. All the rifles are similar except for the three having the ferrous guards and butt plates noted above.

Condition: Vary from excellent to fragmentary.
 Remarks: See Figures 41-44 for details of the rifles.

Figure 35. Carbine, Tower Enfield
 Model 1862
 Scale: 1/8



Figure 37. Firearms and Ordnance page 54 (By Permission of the North Carolina Department of Cultural Resources).

Firearms and Ordnance 55

Figure 36. Rifle, Tower Enfield
Model 1862 (observed on several lock plates
during cleaning).
Scale: 1/8

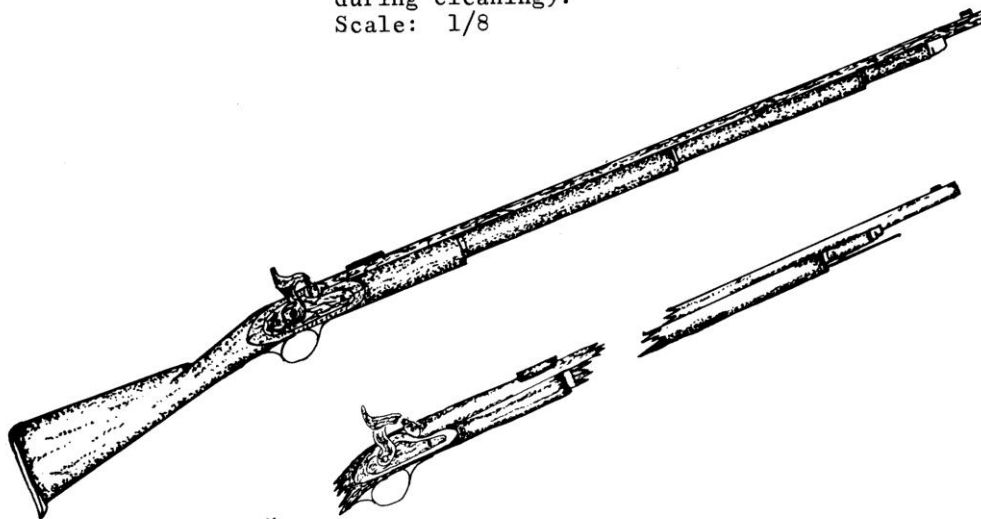


Figure 37. Butt, center, and forearm
fragments of Enfield rifle.
Scale: 1/8

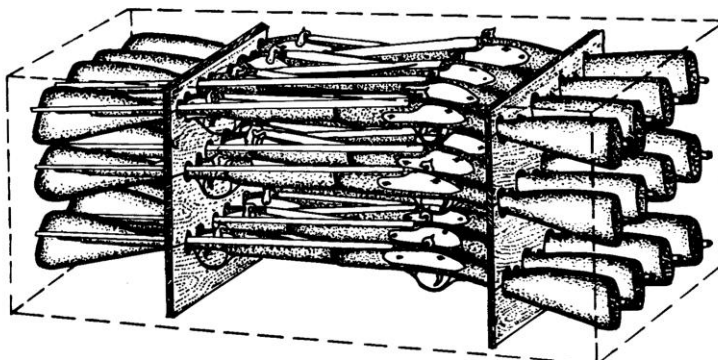


Figure 38. Enfield rifles recovered in cases of twenty-four.

56 Firearms and Ordnance

Figure 39. Shoulder straps found packed in rifle cases.
Scale: 1/2



Figure 40. Rifle case cover
Scale: 1/4

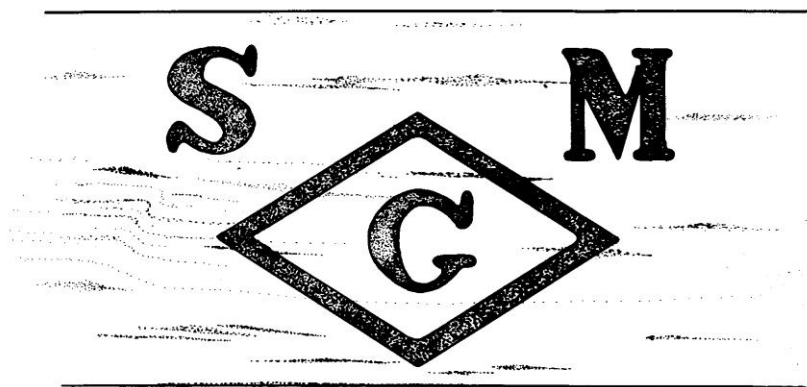


Figure 39. Firearms and Ordnance page 56 (By Permission of the North Carolina Department of Cultural Resources).

Firearms and Ordnance 57

Detail of Enfield rifles:

Figure 41. Maker's mark found on 3 Enfields having no brass parts.
Scale: 2/1

WARD & SON
MAKERS
BIRMINGHAM

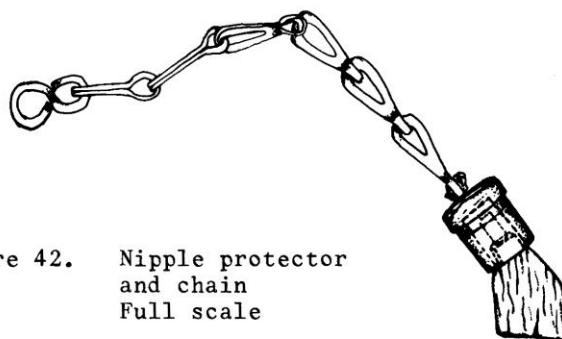


Figure 42. Nipple protector and chain
Full scale

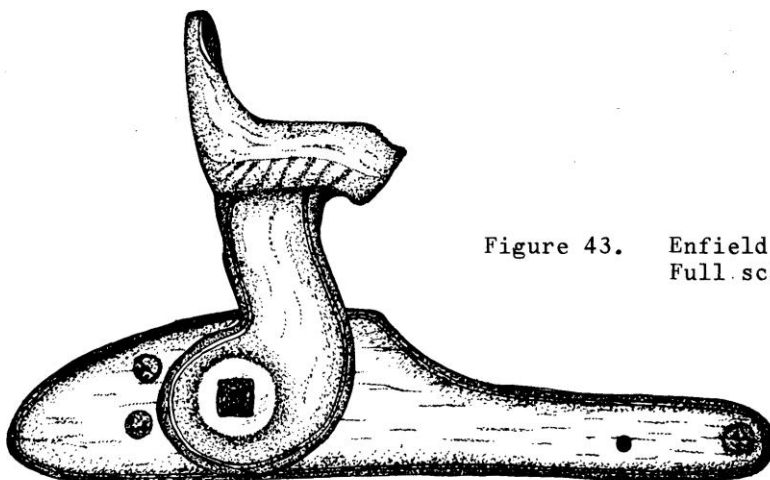


Figure 43. Enfield lock
Full scale



Figure 44. Rifle shipping plug
Full scale

58 Firearms and Ordnance

Article: Shot, 12 pounder Whitworth case (MG-2M)
Recovered: 1 box containing 10 projectiles
Size: Length 9"
Weight: 7 1/2, 8, 8 1/4, 8 3/4, and 9 1/4 pounds
are recorded.
Markings: None
Description: The iron projectiles were packed unarmed
with their cavities empty and without fuses.
They all have similar dimensions but vary
in weight. The variance of the weights re-
corded could be caused by differences in
cavity sizes, decay, and metal density.
Condition: Good

Figure 45. Shot, 12 pounder Whitworth case
Scale: 1/2

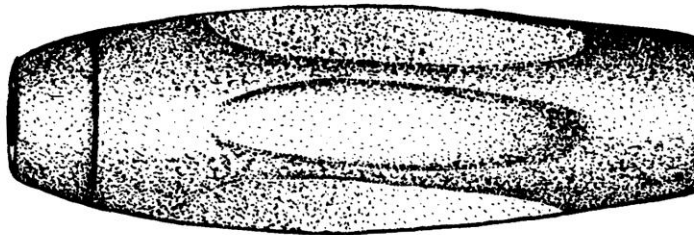
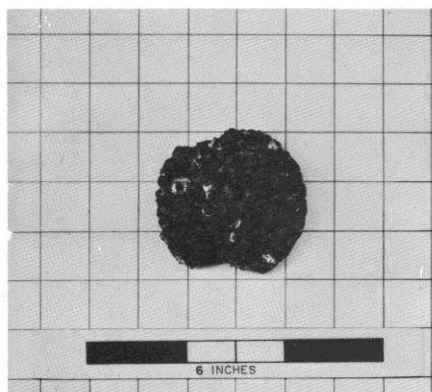


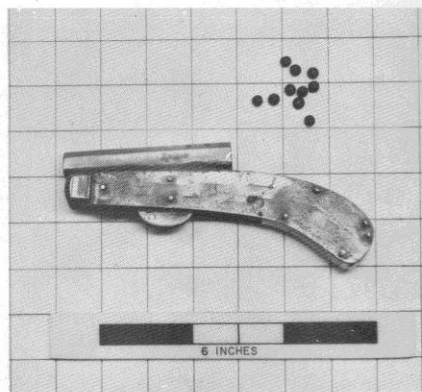
PLATE VI



A. Figs. 29 and 45 Bolt, twelve pounder Whitworth and Shot, twelve pounder Whitworth case



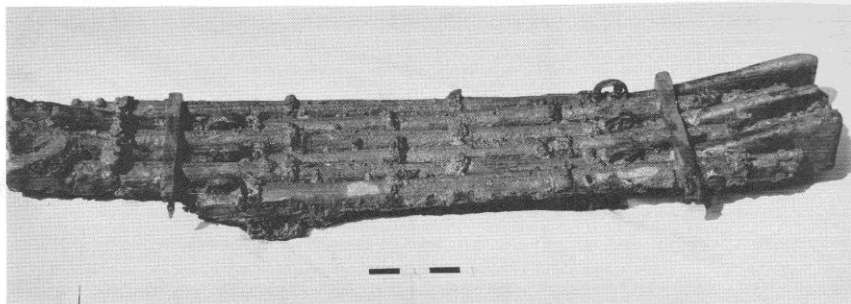
B. Fig. 32 Caps, percussion



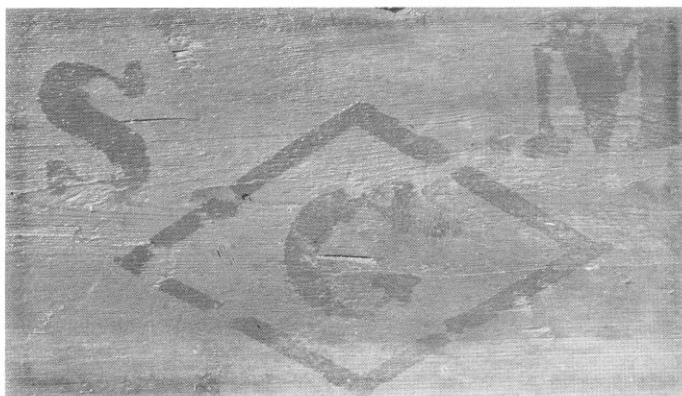
C. Fig. 34 Pistol, Unwin and Rodgers knife

Figure 42. Firearms and Ordnance plate VI (By Permission of the North Carolina Department of Cultural Resources).

PLATE VII



A. Fig. 38 Enfield rifles recovered in cases of twenty-four



B. Fig. 40 Rifle case cover



C. Fig. 41 Maker's mark found on three Enfields

Figure 43. Firearms and Ordnance plate VII (By Permission of the North Carolina Department of Cultural Resources).

APPENDIX C

BRASS MAKER'S MARKS

Rifle	Parts	Letters	Notches	Numbers
MGR 005				
	Trigger Guard	H on tang	3	
	Trigger Plate	DB, sideways H	3	1
MGR 006				
	Trigger Guard			
	Trigger Plate			
MGR 007				
	Trigger Guard		incomplete	
	Trigger Plate		4	
MGR 008				
	Trigger Guard			17
	Trigger Plate	G.II		17
MGR 010				
	Trigger Guard	H.F	3	
	Trigger Plate		3	
MGR 011				
	Trigger Guard		5	2 on tang
	Trigger Plate	DB, sideways H	5	1
MGR 012				
	Trigger Guard	G.II		3
	Trigger Plate	H		3
MGR 013				
	Trigger Guard		5 (2 crossed)	
	Trigger Plate	Sideways H	5 (2 crossed)	
MGR 014				
	Trigger Guard	G.II		4
	Trigger Plate	Small H		4
MGR 015				
	Trigger Guard			
	Trigger Plate	DB, sideways H		1

Figure 44. Table of brass maker's marks.

VITA

Name: Starr Nicole Cox

Address: Department of Anthropology, Texas A&M University
College Station, TX 77843-4352

Email Address: nauticalstarr@gmail.com

Education: B.A., Liberal Arts, University of Kansas, 1997
M.A., Anthropology, Texas A&M University, 2008
Historical Preservation Certificate, Texas A&M University, 2008
CMAC Conservation Certificate, Texas A&M University, 2008

Experience: 2003-present Conservation Research Assistant, Conservation
Research Laboratory, Nautical Archaeology Program, Texas A&M
University, College Station, Texas
2007 Research Diver, Carnauba Survey Project, Texas A&M
University and Center for Maritime Archaeology and Conservation,
Manokwari, Indonesia
2004 Dive Safety Officer, Dominican Republic Survey Project,
Texas A&M University and Institute of Nautical Archaeology,
Dominican Republic
2003 Conservation Internship, Museum of Tropical Queensland,
Townsville, Queensland Australia
2002 Research Assistant, Cais do Sodré, Texas A&M University,
Institute of Nautical Archaeology, and Centro Nacional de
Arqueologia Náutica e Subaquática, Lisbon, Portugal
2002 Research Diver, Arade River Project, Texas A&M University,
Institute of Nautical Archaeology, and Centro Nacional de
Arqueologia Náutica e Subaquática, Portimao, Portugal

Publication: Cox, S. and K. Custer. 2003. Post-Excavation Techniques for
Recording Ship Timbers, In *The INA Quarterly*, Volume 30, Number
3, College Station, Texas.

Presentations: Cox, S. 2008. The Conservation of Waterlogged Civil War Enfield
Rifles. Paper presented at the 2008 Society for Historical Archaeology
Conference, Albuquerque, New Mexico.
Cox, S. 2008. Conservation of Armaments: Strategies for Working on
Composite Artifacts. Paper Presented at the 59th Pittsburgh Conference
on Analytical Chemistry and Applied Spectroscopy, New Orleans,
Louisiana